LOW FLOOR DRIVE UNIT ASSEMBLY FOR AN ELECTRICALLY DRIVEN VEHICLE

BACKGROUND OF THE INVENTION

This invention relates to a unique drive arrangement for electrically driving the wheels of a vehicle in such a way that the floor of the vehicle may be lower than was the case in the prior art.

Mass transit vehicles, such as a bus or trolley car, typically have seats aligned at the lateral sides of the vehicle, with a central aisle extending along the vehicle. The seats are typically at a higher vertical location than the aisle, and thus cover the wheels. It would be desirable to have the aisle positioned relatively low to the ground. This would provide increased passenger space within the body of the vehicle, and may allow the designer to reduce the overall height of the mass transit vehicle. Other advantages to having a lower floor position include improved handicapped access and greater ease in the loading and unloading of passengers.

Mass transit vehicles typically have several axles which support and drive or steer the vehicle. If the axle is a driving axle, then electric motors can be used to generate torque to drive the wheels. In a typical configuration, a centrally located electric motor drives two opposed wheels at the sides of the vehicle by way of a conventional axle. Usually, transmissions or drive shafts extend from the central motor to the axle.

In the prior art, there are relatively large motor, transmission, or axle elements directly below the center of the vehicle. The aisle is typically in the center of the vehicle and normally goes over the axle, thus requiring the floor of the aisle to be relatively high. One known bus moves the floor up by steps over the axle. It is undesirable, however, to have passengers climb steps to reach the aisle and seating areas.

SUMMARY OF THE INVENTION

The subject invention relates to an automotive vehicle drive unit assembly which includes a first driving axle and a second driving axle which together define an axis of rotation. The drive unit assembly further includes a first wheel hub and a second wheel hub which are driven about the axis of rotation. A first gear set drives the first wheel hub and a second gear set drives the second wheel hub. A first electric motor is mounted at an angle relative to the axis of rotation of the first driving axle and drives the first gear set, and a second electric motor is mounted at an angle relative to the axis of rotation of the second driving axle and drives the second gear set.

This invention improves packaging and increases passenger compartment size by moving the electric motors to the sides of the vehicle. This allows the interior vehicle floor to be lowered between the motors resulting in improved utilization of the passenger compartment. Also, the flexibility of mounting the electric motors at various angles with respect to the axis of rotation of the first and second driving axles results in flexible packaging designs for other vehicle components.

BRIEF DESCRIPTION OF THE DRAWINGS

Other advantages of the present invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

Figure 1 is a cross sectional view of a vehicle incorporating the subject invention;

Figure 2A is a cross sectional view taken along line 2-2 of FIGURE 1, showing a first electric motor arrangement;

Figure 2B is a view like FIGURE 2A, but showing an alternative electric motor arrangement;

Figure 3 is a fragmentary view from the inside of the left wheel hub as shown in FIGURE 2, partially broken away and in cross section, and showing a first embodiment of an electric motor arrangement;

Figure 4 is a cross section view from the front of the left wheel as shown in FIGURE 3, and showing the first embodiment of an electric motor mounting arrangement;

Figure 5 is a view like FIGURE 3 but showing an alternative electric motor mounting arrangement; and

Figure 6 is a view like FIGURE 4 but showing the alternative electric motor mounting arrangement.

Figure 7 is a view like Figure 3 but showing an additional electric motor.

Figure 8 is a cross sectional view of a gear box showing an alternative embodiment incorporating a planetary gear set.

DETAILED DESCRIPTION OF a PREFERRED EMBODIMENT

Referring to the Figures, wherein like numerals indicate like or corresponding parts throughout the several views, an automotive vehicle is shown generally at 10. As shown in Figure 1, automotive vehicle 10 includes a passenger compartment 12 defined by a roof 14, two side walls 16, and a vehicle floor 18. A pair of wheels 19,21 are driven by an automotive vehicle drive unit assembly, generally shown at 20, which has a first unit 22 and a second unit 23. It should be understood that vehicle 10 is typically provided with a pair of drive units and several pairs of wheels.

As shown in Figure 2A, the first unit and second units 22 and 23 define an axis of rotation 26. As shown in Figure 3, a first driving axle shaft 24 drives a first wheel hub 28 which revolves about the axis 26 of the first driving axle shaft 24.

A first gear set 30, located adjacent to the first wheel 19, is comprised of a pinion gear 32 and a ring gear 34 which together drive the first wheel hub 28. A first electric motor 36, defining a motor axis of rotation 38, is mounted at a non-parallel angle relative to the axis of rotation 26 of the first driving axle shaft 24. The first electric motor 36 is shown mounted in a horizontal position such that the motor axis of rotation 38 is parallel to the vehicle floor 18 and is perpendicular to the axis of rotation 26 of the first driving axle shaft 24.

As shown in Figure 2A, drive unit assembly 20 further includes a second unit 23 comprising a second driving axle shaft 24, a second wheel hub 28, a second gear set 30, and a second electric motor 36. It is understood that the second unit 23 is a mirror image of the first unit 22. A beam 58 provides a fixed housing extending between the first 22 and second 23 units.

The first 36 and second 36 electric motors can be mounted in various different positions relative to each other. As shown in Figure 2A, the first 36 and second 36 electric motors can be mounted in a generally horizontal position with both electric motors 36 extending forwardly from the beam 58. Where packaging would allow, the electric motors 36 can also be mounted such that they both extend rearwardly from the beam 58. As shown in Figure 2B, the first 36 and second 36 electric motors can be mounted in a generally horizontal position with the first electric motor 36 extending in a forwardly direction relative to beam 58 while the second electric motor 36 extends in a rearwardly direction relative to beam 58. Arranging the configuration so that one electric motor 36 extends forwardly while

the other electric motor 36 extends rearwardly can resolve electric motor weight balance issues that arise when both motors extend in the same direction from the beam 58.

As can be seen in Figure 3 and 4, a first gear box 40 houses the first gear set 30 and is rigidly connected to the first electric motor 36. A motor drive shaft 42 extends from the electric motor 36, along the motor axis of rotation 38, and drives the pinion gear 32. The pinion gear 32 meshes with the ring gear 34 which revolves about the axis 26 of the driving axle shaft 24. As the ring gear rotates, it drives the driving axle shaft 24 which turns the wheel hub 28. As can be seen in Figure 4, gear box 40 is fixed to beam 58.

A planetary gear set, shown generally at 46 in Figure 4, can be used to achieve greater overall gear reduction. The planetary gear set 46 can either be located adjacent to the wheel hub 28 or can be incorporated into the gear box 40. The planetary gear set 46 shown in Figure 4 is located adjacent to the first wheel hub 28 and is driven by the first driving axle shaft 24. The planetary gear set 46 shown in Figure 8 is incorporated into the gear box 40. Regardless of its location, the planetary gear set 46 includes a sun gear 48, planet gears 50, and a ring gear hub 52. Each planet gear 50 is attached to a single planetary spider 53 by a corresponding planet pin 51, thus forming a planet gear assembly, as shown in the enlarged view of the planetary gear set 46 in Figure 8. The planet gear assembly is inserted into the ring gear hub 52 such that the teeth of the planet gears 50 mesh with the teeth of the ring gear hub 52.

In a typical configuration there are three planet gears 50 in a planet gear assembly but it is understood that a different number of planet gears 50 can be used. When the planetary gear set 46 is located adjacent to the wheel hub 28, as shown in Figure 4, the sun gear 48 is attached to and driven by the first driving axle shaft 24. As the sun gear 48 rotates, it meshes

simultaneously with each of the planet gears 50 in the planet gear assembly. The planet gears 50 mesh with the ring gear hub 52 which results in the turning of the first wheel hub 28. The entire planetary gear set 46 is housed within a planetary hub 54 located adjacent to the first wheel hub 28. It is understood that the drive unit assembly 20 does not require a planetary gear set 46 for operation. The planetary gear set 46 is an optional feature of the drive unit assembly 20.

As shown in Figure 8, the planetary gear set 46 can also be incorporated into the gear box 40 instead of being located adjacent to the wheel hub 28. Incorporating the planetary gear set 46 into the gear box 40 is a unique location for the planetary gear set 46. Typically, this location has been used by a differential which includes a ring gear and a pinion gear which drive axle shafts which in turn drive the wheels. With independent electric motors 36 there is no need for a differential or for any direct mechanical link between opposing wheels. By incorporating the planetary gear set 46 into the gear box 40, the need for a planetary hub 54 is eliminated which decreases the vehicle weight, gives a broader selection of wheel equipment and wheel end features, and reduces overall cost.

Figure 5 and 6 show an alternate embodiment of the mounting arrangement for the first electric motor 36. The first electric motor 36 is shown mounted in a vertical position such that the motor axis of rotation 38 is perpendicular to the vehicle floor 18 and is perpendicular to the axis of rotation 26 of the first driving axle shaft 24. In a typical configuration, the first electric motor 36 is mounted either in a horizontal or vertical position. However, the electric motor 36 can be mounted at any angle with respect to the vehicle floor 18 and the axis of rotation 26 of the first driving axle shaft 24.

Figure 7 shows an alternate embodiment of the drive unit assembly 20 in which the first unit 22 includes a third electric motor 56, in parallel driving relationship with the first electric motor 36. The third electric motor 56 is also used to drive the first gear set 30. The second unit 23 is a mirror image of the first unit 22 and includes a fourth electric motor 56, in parallel driving relationship with the second electric motor 36. The fourth electric motor 56 is use to drive the second gear set 30. The use of a third 56 and fourth electric motor 56, where packaging space is available, allows smaller gears and motors to be used, thus reducing the necessary size for the system.

With the present invention, the benefits as shown in particular in Figure 1 are achieved. By mounting the motors at the sides of the vehicle, the center of the vehicle floor may be lowered significantly than compared to the prior art. In addition, since the motors themselves are connected to drive the wheels to a non-parallel angle, they do not extend towards the center of the vehicle from the wheel for any undue amount. Thus, the lower floor can begin at a laterally outer position. If the motors extended on an axis parallel to the axis of the wheel, the motor would require a higher floor for more of the lateral width of the vehicle.

The invention has been described in an illustrative manner, and it is to be understood that the terminology which has been used is intended to be in the nature of words of description rather than of limitation.

Another method of mounting the motors for the present invention is disclosed in co-pending patent application number _____ entitled "Suspension Drive Unit Assembly for An Electrically Driven Vehicle". Another mounting of the motor relative to

the axle of the wheel hub is disclosed in co-pending patent application number_______________entitled "Space Saving Connection for Electric Drive Motor to Wheel Hub".

The invention has been described in an illustrative manner, and it is to be understood that the terminology which has been used is intended to be in the nature of words of description rather than of limitation.

Obviously, many modifications and variations of the present invention are possible in light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims, wherein reference numerals are merely for convenience and are not to be in any way limiting, the invention may be practiced otherwise than as specifically described.